INCIDENT INVESTIGATION REPORT
Crude Oil Discharge to Lake Michigan
Whiting Business Unit

Incident Date: March 24, 2014
Investigation Start Date: March 26, 2014
MI/HiPo Notification Date: March 25, 2014
Report Issued: August 20, 2014
Traction Report: 4674318

Table of Contents

1 Executive Summary

The BP Products North America, Inc. Whiting Refinery discharged a mixture of water and crude oil from the refinery's cooling water outfall into Lake Michigan on March 24, 2014. The discharge began at approximately 4:30 p.m. The Whiting Refinery mobilized its Incident Management Team and executed a plan to minimize the amount of oil getting into the lake and to mitigate the impact of oil that did get into the lake. The release was an estimated 15 to 39 barrels of crude oil into Lake Michigan.

Refinery personnel determined that crude oil from No. 12 Pipestill had flowed backwards through a temporary quench line that connected the No. 12 Pipestill brine line to the Once Through Cooling Water (OTCW) system. The temporary connection had been installed to provide cold water to reduce the temperature of the brine because the brine heat exchangers were not providing adequate cooling due to fouling. The Refinery isolated the temporary connection the evening of March 24, 2014 and permanently removed it on March 25, 2014.

BP formed an investigation team lead by BP experts and personnel from outside the Refinery to determine the cause(s) of the incident and make recommendations to avoid recurrence. The investigation team found that the incident occurred when an upset in the No. 12 Pipestill desalters caused crude oil to flow through the desalters and into the brine system. Pressure in the brine line exceeded the pressure in the OTCW system at which time one or both of the 1-inch check valves in the temporary quench water line failed, allowing brine and oil to flow into the OTCW system.

The investigation team determined that a combination of the following conditions and causes led to the March 24th incident. None of these causes or conditions alone would have resulted in the incident.

- An upset in the desalters led to higher than normal levels of crude in the brine and an increase in pressure in the brine line, creating the potential for backflow of crude and brine to the OTCW system. Despite these conditions, the brine system and desalters were operating within design parameters.
- Grooves developed in the valve bodies of the two 1-inch check valves allowing the pistons to be lodged in the open position. The grooves were most likely caused by galvanic and/or fretting corrosion which may have been accelerated by the flow conditions within the valve. Although the check valve type was not specified to installers, this is a typical check valve for this application and BP and Whiting specifications do not disallow this type of check valve.
- The temporary line was not installed as designed. The design called for one 2-inch check valve and two 1-inch check valves; however; the 2-inch check valve was not installed.
- Corrosion and subsequent fouling of the E-152 heat exchangers was caused by the interaction of ammonia with the copper/nickel alloy metallurgy of the exchanger tubes based on an inadequate design. This interaction was exacerbated by the high concentration of dissolved oxygen in the cooling water. The fouling led to inadequate cooling of the brine which prompted the installation of the temporary quench water line.
- Electrical grids in the desalters were not properly wired during construction, which reduced their performance and contributed to oil being present in the brine. The wiring problems have been resolved and the desalters are functioning as intended.
- The management of change (MOC) process for installation of the temporary line considered the risk of backflow but did not identify the risk of oil entering the OTCW system, passing through the No. 6 Separator, and subsequently reaching the lake.

The Whiting Refinery has taken the following actions:

- The temporary quench line was removed.
- Conducted a thorough review of the connections from process piping to the OTCW system and sealed or blinded any connections.
- All OTCW utility stations were tagged with a sign stating that shift supervisor must grant approval before any hook-ups are made to a utility station.
- Corrected the wiring of the electrical grids on the desalters.
- Changed the metallurgy of the E-152 heat exchanger tube bundles.

- Controlled the level of dissolved oxygen in the desalter water with an oxygen scavenger compound to reduce the corrosion of carbon steel.

The investigation team makes the following recommendations:

- Complete additional testing to determine the rate of galvanic corrosion between carbon steel and stainless steel in lake water. Based on the results of this testing, update Whiting technical practices for selecting valves and clarify/reinforce velocity limits for piping and components. Share this learning with BP and the industry.
- Where the combined corrosion mechanisms could occur in similar check valves in similar service, verify the design and take necessary corrective action.
- Re-emphasize to engineers the requirements for developing Job Notes to provide instructions for repairs and new installations.
- Re-emphasize management expectations that the existing MOC process be followed rigorously.
- Enhance the Whiting self verification program to assure conformance with high priority processes, including the MOC and Maintenance Work Processes.
- Control the injection of free water into No. 12 Pipestill crude feed to maintain operating limits.
- Install oil detection systems upstream of No. 6 Separator to provide advanced notice that oil is present in the OTCW system.
- Remove solids from No. 6 Separator to increase residence time and thereby decrease the likelihood that oil will pass through the separator.
- Evaluate options to improve the capability of No. 6 Separator to effectively remove oil from the OTCW system. Implement recommended option(s) from this evaluation.

The Whiting Refinery will prioritize and establish the schedule for implementing these recommendations.

2 Background Information

2.1 Scope

The Whiting Refinery discharged a mixture of water and crude oil from the refinery's cooling water outfall into Lake Michigan on March 24, 2014. The discharge began at approximately 4:30 p.m. BP Operations and the response team executed a plan to deploy boom, contain the oil and stop the discharge.

The scope of this investigation was to identify the potential causes and contributing factors of the discharge of crude oil to Lake Michigan on March 24, 2014. As the spill response was not causal to this incident, it was not included in the scope of this investigation.

2.2 No. 12 Pipestill Process Description

Overview

The purpose of No. 12 Pipestill (12 PS) is to fractionate crude oil into various products based upon boiling range and send them to other refinery units for further processing.

Crude oil is heated and mixed with water to remove salts, sediment, and other contaminants. The mixture is sent to a series of desalters, where electrical grids promote coalescing and settling of the water/brine, allowing desalted crude oil to continue through the process.

The desalted crude oil is further heated and sent to the primary tower, where it is fractionated into intermediate hydrocarbon streams. See Figure 1 for a process flow diagram of the PS 12 desalters.

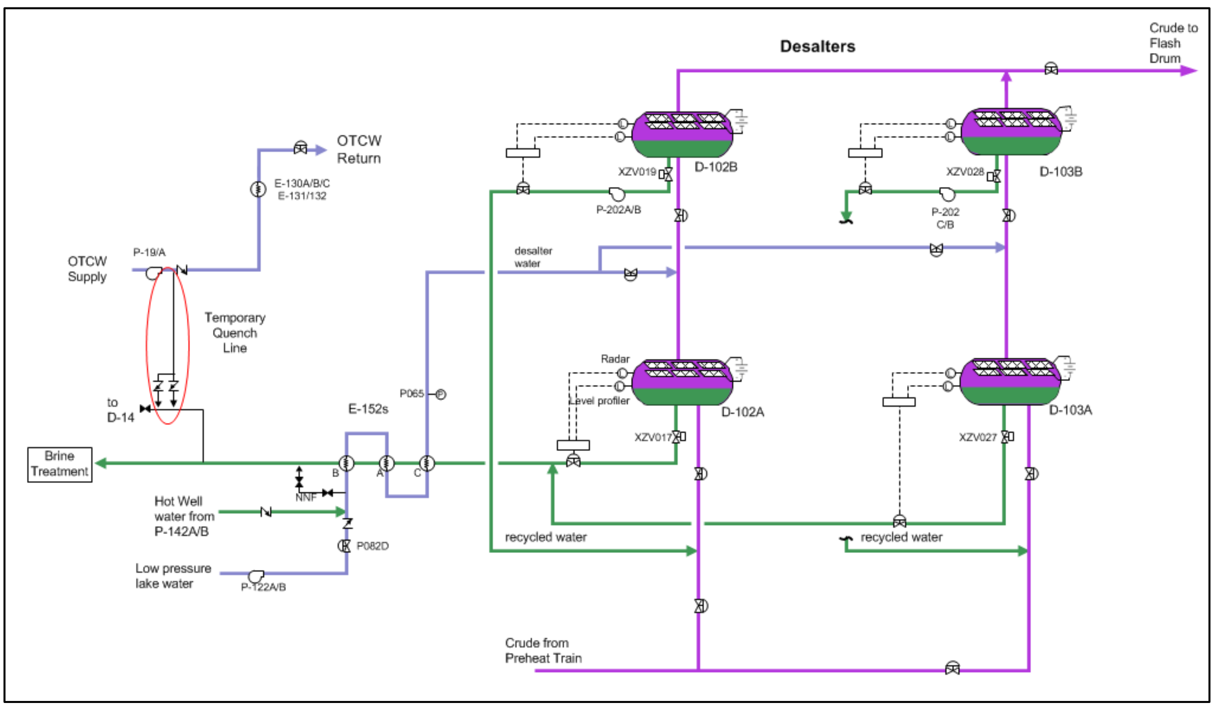


Figure 1: No. 12 Pipestill Desalter Process Flow Diagram, including temporary quench line.

2.3 No. 6 Separator Process Description

The purpose of No. 6 Separator is to remove any free phase hydrocarbon that may be present in the OTCW before discharge of the water to Lake Michigan. The flow ranges from 55 to 85 million gallons per day and the residence time varies from 50 to 90 minutes. Separation works by allowing time for oil droplets to float to the surface based on the difference in density between the water and oil. Once at the surface, oil is captured and removed.

Flow comes in from the west and distributes evenly through eight parallel paths. Half of the flow combines at the southern end. The total flow combines at the northern end and flows out through outfall 002 and discharges at the shoreline of Lake Michigan (Figure 2).

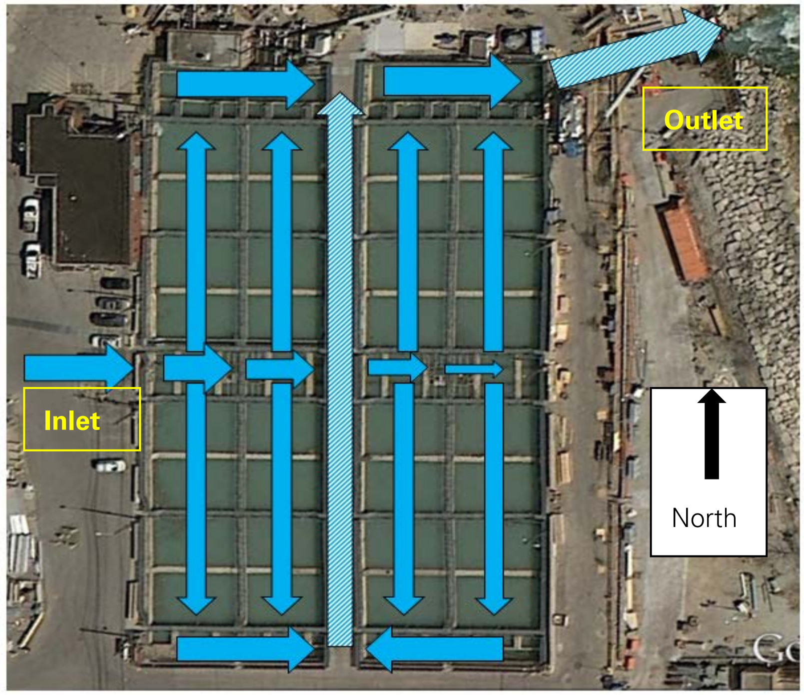


Figure 2: Flow pathways through No. 6 Separator.

There is an instrument, called an oil slick watch, at No. 6 Separator that alarms when oil is present in the OTCW flowing into No. 6 Separator. When this alarms, the Lakefront operator visually checks for the presence of oil in No. 6 Separator.

2.4 Description of Temporary Quench Line

The temporary quench line was proposed to cool the brine that was not being adequately cooled by the E-152 heat exchangers due to fouling. A Temporary MOC (M20133592-001) was conducted to assess and address risks before the installation of the temporary quench line. The temporary quench line was installed on October 11, 2013 and put in service on October 12, 2013.

The temporary quench line drew OTCW from a bypass near the P19A pump discharge (Figure 3). The quench line consisted of a 2-inch stainless steel braided hose connected to a 1-inch piping manifold with two 1-inch check valves that were connected to the brine system through two 1-inch bleed valves near the D-14 junction box (Figure 4).

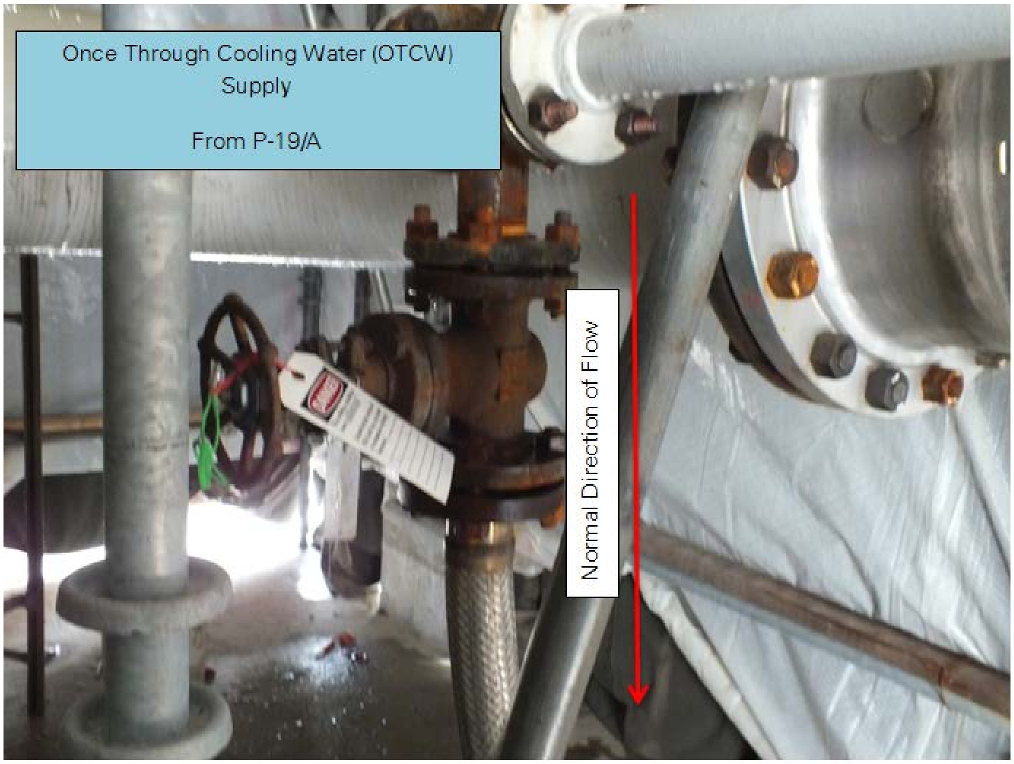


Figure 3 Connection of temporary quench line to the P-19A OTCW supply pump

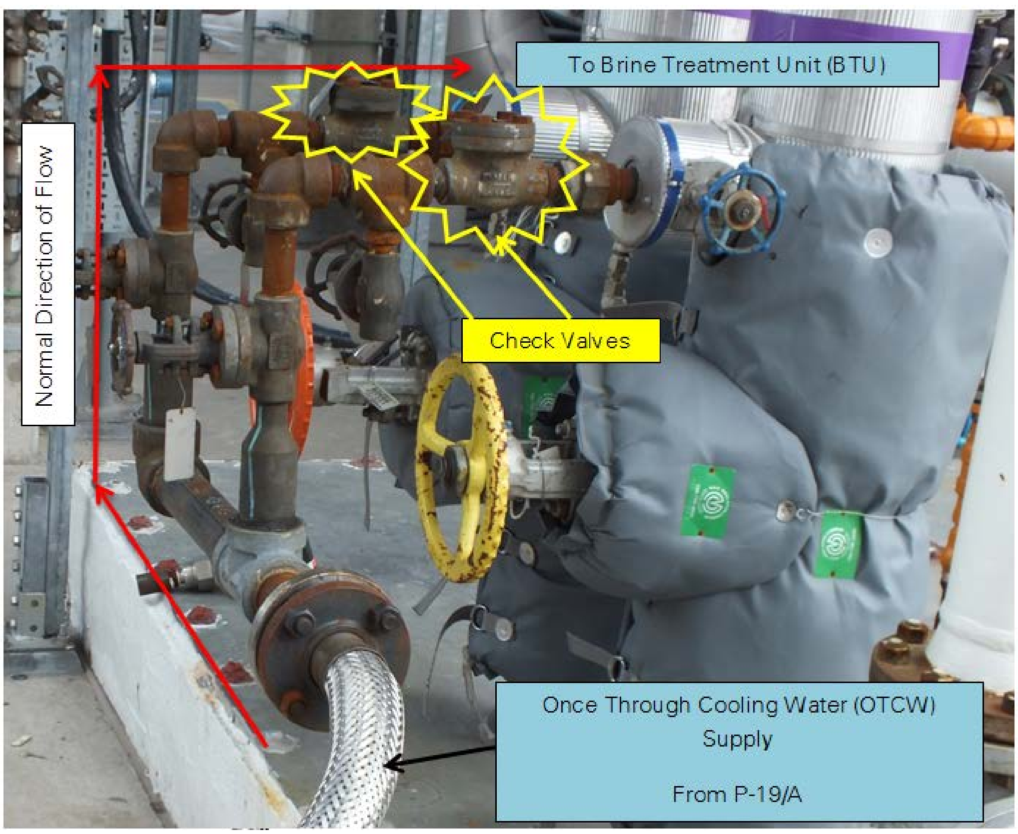


Figure 4 Connection of the temporary quench line 1-inch manifold (including two 1-inch check valves) to the brine system near D-14 junction box.

3 Incident Description

3.1 Incident

During the morning of March 24, 2014, the 12 PS desalters started to show indications of a growing emulsion layer evidenced by low voltage and oil and water level changes. Operations responded with several actions to evaluate and resolve the growing emulsion layer. Just after noon, a primary crude furnace tripped off line due to water in the crude. This water caused instability and low flow readings in the ultrasonic flow meters, which activated the low flow trip of the crude furnaces. Shortly thereafter, a second primary furnace tripped off line also due to low flow. Without the furnaces providing heat to the primary tower, the crude preheat train did not adequately heat the incoming crude, resulting in the desalter temperature decreasing to below 250F. The voltage, level variability, and furnace trips were all indications of desalter carry over (water in crude) and carry under (crude in brine). Troubleshooting activities continued, including a decision to remove make-up water from the desalters. At 2:52 pm, the brine control valve on the D-103A desalter automatically opened completely in response to the controlling level instrument indicating a high level of water in the desalter. At approximately the same time, the bypass around the E-152 brine/desalter water exchanger was opened to divert hot-well[1] water feeding the desalters to the brine outlet. Opening the control valve and rerouting the hot-well water to the brine line resulted in the pressure in the brine line exceeding the pressure of the OTCW system. The brine and OTCW systems were connected via the temporary quench water line. One or both of the check valves (intended to prevent reverse flow) on the temporary quench water line failed and allowed brine and crude from the desalters to backflow through the temporary quench water line into the OTCW system. When this bypass was opened, pressure indication on the exchanger desalter water feed outlet in essence became an indication of the brine line pressure. This pressure reading confirmed the brine system pressure was approximately 40 psig greater than the OTCW system. At 4:43 pm, one of the desalter brine Emergency Block Valves (EBVs) automatically closed, resulting in lower flow and pressure in the brine line, and halting the reverse flow. The level control valves (LCVs) on each desalter train were put in manual and closed by the console operator at 4:58 pm stopping the flow of brine.

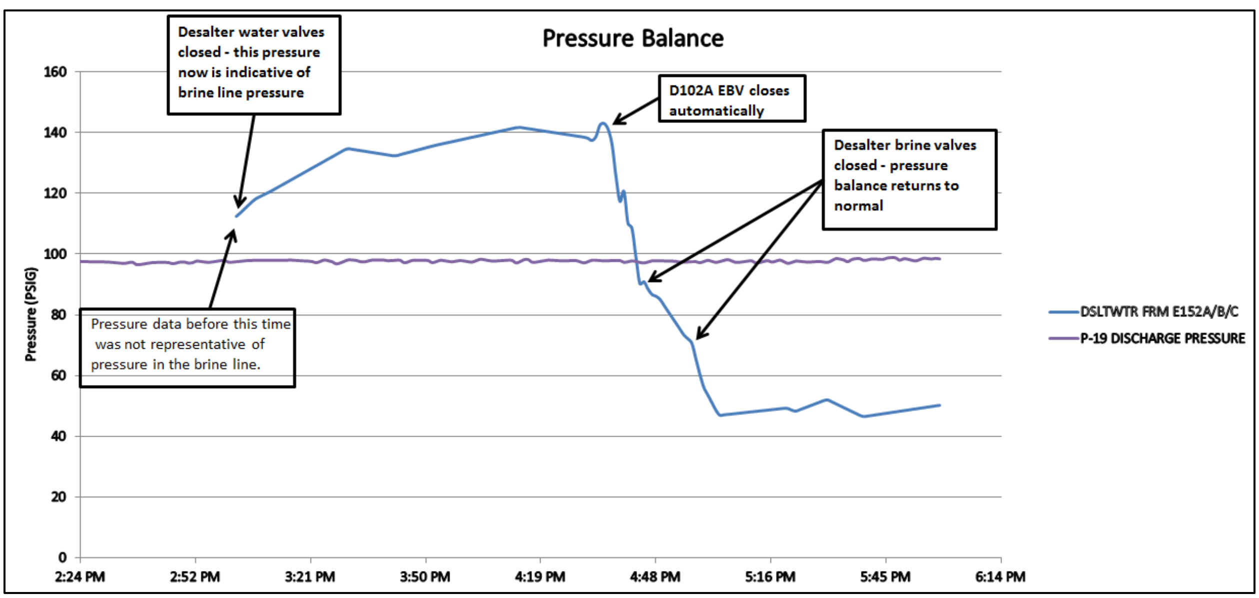


Figure 5: Pressure balance between the brine line and OTCW system.

At 4:04 pm, at the Lakefront, an alarm indicated oil on the OTCW entering No. 6 Separator. Lakefront operations responded by putting sorbent pads on all compartments of No. 6 Separator and called out vacuum trucks to remove oil from the surface. A refinery wide radio call occurred at 4:22 pm requesting

[1] Hot-well water consists of steam condensed in the overhead system of the vacuum tower.

all units to look for sources of oil in the OTCW. At 4:30 pm, an oil sheen was observed on Lake Michigan.

In response to the radio call regarding oil in the OCTW, 12 PS operations personnel (and personnel throughout the refinery) reviewed possible pathways for crude oil to flow into the OTCW system. The temporary quench water line was identified as a possible source and was closed at approximately 5:30 pm as a precautionary measure. Later that evening, lab results for sulphur and American Petroleum Institute (API) gravity indicated that the oil from No. 6 Separator was the same as oil from 12 PS. Early the next morning, on March 25th, the simulated distillation laboratory analytical results of the oil collected from No. 6 Separator indicated the same composition as 12 PS crude feed. Later that morning, after oil was discovered at the base of the P-19 cooling water pump, a process engineer reviewed 12 PS process data and identified the reversed pressure balance between brine and OTCW systems. At that point, the Whiting Refinery determined that oil had leaked from the P-19 pump seal, an indication that brine and crude had backflowed from the brine line to the P-19 pump. That afternoon the temporary quench water line between the OTCW and brine was physically removed.

3.2 Incident Response

After discovering the discharge on Monday, March 24, 2014, the Whiting Refinery promptly began response efforts and notified all appropriate government agencies, including the police and fire department, US Coast Guard (USCG), the US EPA (EPA), and the Indiana Department of Environmental Management.

The Whiting Refinery worked closely and cooperatively with the EPA and USCG to carry out an effective response. The Whiting Refinery engaged in a number of response activities, including the installation of boom around the outfall (see Figure 6) and in a cove between the refinery's wastewater treatment plant and a neighboring steel mill. The Whiting Refinery response crews vacuumed oil out of the water and cleaned up the oil that reached the shore.

The Whiting Refinery also initiated response activities to limit the amount of oil that reached the lake, including using boom and sorbent pads within No. 6 Separator.

No visible oil sheens on the water or accumulations of oil were reported in any area outside of the cove.

Shoreline assessment teams with members from BP, USCG, and EPA conducted multiple surveys following the discharge. On April 4, an assessment team did a visual inspection and found no remaining oil on the lake or the beach, and concluded that no additional response activities were needed.

Figure 6: Aerial photo showing deployment of boom at the No. 6 Separator outfall.

4 Incident Analysis

The investigation into the release of an estimated 15 to 39 barrels of crude oil into Lake Michigan from the No. 6 Separator outfall identified causes in the following areas:

1. The initiating event that occurred at 12 PS consisted of:
    a. higher than normal pressure in the brine line and
    b. the presence of more crude oil in the brine line than under normal circumstances.
2. A temporary piping connection was made from the OTCW system to the brine line to lower the brine temperature (i.e., quench the brine).
3. The backflow prevention on the temporary quench line was not effective.
4. The No. 6 Separator was not capable of removing the oil that backflowed into the OTCW system.

4.1 Initiating Event

An operational upset occurred at the 12 PS desalters on the day of the incident. This upset alone would not have caused the incident in the absence of the causal factors listed in sections 4.2, 4.3 and 4.4, below. The upset led to two consequences that initiated this event: 1) the pressure in the brine line (approximately 140 psi but still within safe operating limits) exceeded the pressure in the OTCW system (approximately 100 psi) and 2) more crude oil was present in the brine than under normal circumstances. The increased pressure in the brine line was caused by routing the hot-well water to the brine line, and the increased flow to the brine line from the desalters as a result of the control system opening the brine level control valves in response to high water levels indicated in the desalters. The hot-well water was rerouted after operators shut off the water to the desalters to control the desalter upset. The 12 PS operations procedure for managing *Excess Water in Crude* did not address specific steps for removing water from the desalters; therefore operators did not close the desalter water level control valves immediately as they were occupied addressing higher priority issues in the unit (e.g. crude furnace trips). These two conditions are within design parameters of the desalters and brine system; however, these conditions initiated the event that led to the backflow of oil into the OTCW system.

The upset in the desalters was caused by a growing emulsion layer in the desalters due to water being injected into the crude feed ahead of the crude pumps causing a tight emulsion. This led to water being carried over to the crude furnaces causing instability in the ultrasonic flow meters, which activated the low flow trip of the crude furnaces. When the crude furnaces tripped, this caused the desalter temperature to decrease, making resolution of emulsion difficult. The source of the water being injected before the crude pumps was from an internal slop system. The D218 oil/water separator in the internal slop system is designed to be operated manually and intermittently, but not continuously. It was being operated continuously and at a reduced rate at the time of the event, which allowed water to be carried over into the crude feed.

The electrical grids in the desalters were not properly wired making it more difficult to minimize the emulsion. The electrical grids create an electrical field in the crude and emulsion to coalesce the water and allow it to settle out of the crude and emulsion; however, since the grids were not wired correctly, it was less effective in resolving the tight emulsion. The wiring of the electric grids was completed during WRMP construction and verified by the manufacturer. The desalter electrical grids have been re-wired and the desalters are now functioning as expected.

The successful operation of the unit running heavy crude after the desalter grids were rewired demonstrates that heavy crude being run at the time of the incident did not materially contribute to this event. Other properties of the crude and crude mixture were further investigated and were also determined not to have contributed to the difficulty resolving the emulsion in the desalters at the time of the incident.

4.2 Temporary Quench Line

The purpose of the temporary quench line was to cool the brine leaving the desalters to a temperature within the operating limits of the Brine Treatment Unit (BTU). This temperature reduction is typically accomplished through the E-152 heat exchangers; however these heat exchangers have not functioned at the intended capacity because of fouling in the exchangers. Fouling of the exchangers inhibited heat transfer from the hot brine to the cooler desalter make-up water.

Increased fouling was first identified in the E-152 heat exchangers in September 2013. The fouling issue was being investigated and steps were being taken to address it; however, despite the trouble-shooting efforts, the heat exchangers were not providing adequate cooling of the brine.

In October 2013, the Refinery decided to add a temporary quench line to cool the brine until the fouling issue could be resolved. The Refinery decided to bring in lake water from the OTCW system due to the proximity to an available injection point to the brine line near the D-14 junction box[2]. Other options for quenching the brine were rejected due to operational impacts to the desalters or increased risk to other operations.

The fouling of the E-152 heat exchangers was the only reason for the installation of the temporary quench line from the OTCW system to the brine line. The cause of the fouling was investigated by a team of engineering and metallurgical experts from BP. The team concluded that the fouling was caused by two mechanisms:

1. Corrosion of carbon steel, the primary metallurgy of 12 PS, in the presence of dissolved oxygen (6-8 ppm) and high temperature 240°F to 290°F. The corrosion products from carbon steel upstream of the exchangers are deposited in the E152 tubes causing fouling.
2. Corrosion of copper from the copper/nickel alloy bundles in the heat exchangers in the presence of dissolved oxygen (6-8 ppm) and ammonia (36 ppm). The copper from corrosion of the copper/nickel alloy deposits on the carbon steel serve as cathodes inducing galvanic corrosion. [3]

Copper/nickel alloy is not the optimal metallurgy for the tube bundles in water service containing ammonia. The selected metallurgy resulted from an assessment of process conditions during design of the exchangers that did not include the presence of ammonia in the stream. Ammonia would be expected to be present in the hot-well water, one of the streams composing the desalter make-up water.

The presence of dissolved oxygen in contact with carbon steel in 12 PS was recognized during the design; however, it was not mitigated.

4.3 Backflow Prevention

Under the conditions of the initiating event (increased pressure and crude in the brine line) the presence of the temporary quench line allowed oil to backflow into the OTCW system; however, the primary cause of this backflow was the failure of one or both of the check valves that were installed in this temporary quench line in the presence of elevated pressure in the brine line. One or both of the one-inch check valves (see Figure 4), installed in parallel in the manifold connecting to the brine line, failed to close on back pressure from the brine line.

Det Norske Veritas (DNV) conducted mechanical and metallurgical testing of the two one-inch check valves and determined that one or both of the valves failed due to grooves that developed in the valve bodies while in service. Given the operating conditions and materials of construction, the two most likely primary corrosion mechanisms are galvanic corrosion and fretting corrosion, which may have been accelerated by the flow conditions within the valve. These mechanisms are described below:

- Galvanic corrosion may have occurred where the carbon steel valve body was in contact with the 410 stainless steel piston in the presence of an electrolyte (lake water).
- Fretting corrosion likely occurred due to small vibrations of the piston caused by turbulent flow which helped break apart and facilitate the removal of corrosion products and allows continuous

[2] D-14 is a sewer sump that allows oil in the sewer to collect for recovery while storm water and sewered process water continue on to the lakefront for processing.

[3] Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially to another when both metals are in electrical contact, in the presence of an electrolyte.

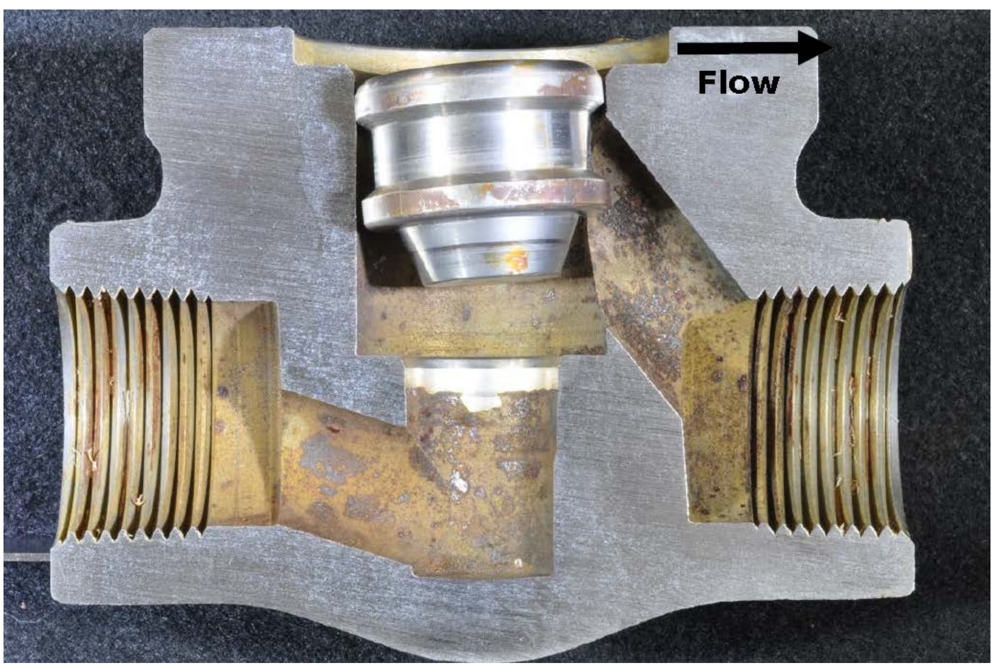
contact of the 410 stainless steel piston and the carbon steel valve body. The turbulent flow was caused by elevated flow velocity through the check valve which was approximately 25 feet per second (fps), compared to a recommended maximum velocity of 10 fps[4].

The velocity of water through the valve may have contributed to the removal of corrosion products, accelerating the galvanic and/or fretting corrosion. BP valve experts and metallurgists had not experienced similar failures of piston check valves due to a combination of these corrosion mechanisms in similar service.

Mechanical testing completed by DNV did not replicate the failure that occurred during the incident likely because the test flow rates could not replicate the high flow rates while the valves were in service. Nonetheless, DNV concluded that the grooves in the valve body prevented the piston from seating during backflow conditions allowing the crude and brine to backflow into the OTCW System (see Figure 7).

Instructions provided to Maintenance for the installation of this line did not specify the type of check valve to be used. The piston check valve used is a common check valve referenced in numerous Whiting line class specifications and was likely selected by Maintenance during installation because this is a typical valve for this size piping in a variety of refinery services.

If more detailed engineering had been completed and the specific check valve type had been provided to Maintenance, it is not known which check valve type would have been selected; however, it is possible that this type of check valve would have been selected anyway. Line class specifications and technical practices are used by engineers when designing piping systems and provide recommendations on types of check valves to be used. The Whiting line class specifications[5] as well as BP and industry guidelines on valve selection did not indicate that this type of valve was not recommended for this application. In fact, the use of these different design documents can lead to different conclusions about the appropriateness of the piston check valve for this application. In addition, there are no warnings in these documents about the possibility of galvanic corrosion in piston check valves in the presence of an electrolyte. In conclusion, the use of this check valve in this service is consistent with industry practice.



[4] WBU GP 42-1010 *ASME B31.3 Piping Systems*
[5] Whiting line class specifications were derived from former Amoco specifications.

Figure 7: Grooves (not visible in this photo) in the valve body allowed the piston to rest in a tilted position preventing it from reseating during back flow conditions. The direction of normal flow is shown.

There were no other check valves installed on the temporary quench line. The design included a two-inch check valve to be installed on the other end of the temporary quench line, near the P19A pump. This two-inch check valve was not installed but the 2 one-inch check valves added to the original design as a result of the MOC risk discussion were installed. The lay-out of materials to be installed was completed based on a hand sketch and verbal instructions. No "Job Note" was developed for the installation of this temporary quench line. A Job Note" would include detailed instructions for the installers describing the work needed. Whiting Resource Guide RG 22.0 requires a Job Note for this type of work; however the Maintenance Work Process does not specifically require a Job Note.

The Maintenance Work Process requires that a "Job Plan" be prepared for any work completed; however no Job Plan was completed. Although not described in the Maintenance Work Process there is a general practice at the Whiting Refinery that the complete Maintenance Work Process is not followed for "break-in" work[6]: it was reported that it is not uncommon that a Job Note is not completed for break-in work. This job was identified as break-in work. An email containing a list of materials was provided but was not used when laying out the job. This list of materials included the two-inch check valve that was omitted during installation. The installation of the line followed the lay-out of the material and the installers would typically install the materials that had been laid out without additional instructions. Therefore, it is likely that it was during the layout of the materials that the 2-inch check valve was omitted.

The job walk-down, part of the MOC process, is the main step to assure that the work has been completed as designed. The job walk down was not comprehensive for this temporary line and therefore did not identify that the two-inch check valve was not installed. The pre-start up safety review was signed-off indicating that a job walk-down had been performed.

The MOC process is used to evaluate changes being considered, identify risks and develop and implement appropriate mitigations before the change is implemented. In the case of this change, the risk of oil backflowing from the brine line into the OTCW system, passing through the No. 6 Separator, and subsequently reaching Lake Michigan was not identified during the MOC, and therefore was not adequately mitigated. The MOC team focused on the potential for backflowing brine to corrode the stainless steel 2-inch hose, which lead to the additional 1-inch check valves being installed. When evaluating a completed risk assessment, it is always difficult to predict what a team would have done to address a risk that was not identified during a risk evaluation process. In this MOC, there were several specific actions that may have led to the team's lack of recognition of this risk:

- The team completed the basic level of risk review (Level 1) where a Level 2 review would have been more appropriate. The initial evaluation identified that a Level 2 risk review was required; however, during the risk evaluation, it was reclassified to a Level 1 based on an incomplete analysis of the risk factors.
- Key stakeholders affected by the change or knowledgeable of the risks (Environmental and OTCW System personnel) were not involved in the risk review meeting where the risks were discussed. This discussion is one of the best opportunities for identifying risks with participants knowledgeable of the change and the potential risks.
- The required Piping Evaluation Checklist was not completed or reviewed by the team. This form included questions directly related to risks of oil backflowing into water systems.

Personnel involved in this MOC reported that they believed that not all of the steps in the MOC process were required (e.g. not completing checklists before the risk review meeting). This belief does not appear to be recognized by management, primarily due to the absence of an effective self-verification process to assure conformance with the MOC process. Although several metrics on MOC completion

[6] Break-in work is maintenance work that has a level of urgency that requires a break into the scheduled maintenance work.

were being captured and reported at Whiting, these metrics were not equivalent to a self verification process as perceived by management. People involved in this MOC thought they were increasing efficiency without increasing risk.

4.4 No. 6 Separator Capability

The oil flowing into No. 6 Separator from 12 PS exceeded the oil removal capacity of No. 6 Separator. The capacity of No. 6 Separator to remove oil is dependent on the inlet volume of oil and water as well as the rate at which the oil separates from the water. Much of the oil was removed at No. 6 Separator through the application of sorbent pads, sorbent boom, and vac trucks. The oil that did not separate out in No. 6 Separator was entrained in the discharge through Outfall 2 into Lake Michigan. One of the reasons that some of the oil did not separate out, and remained entrained as an emulsion, is the tight emulsion that was generated because water was added to the crude stream upstream of the crude pumps which have a high pressure differential. A tight emulsion takes longer to separate out, and these oil particles did not separate out in No. 6 Separator.

There is an instrument, called an oil slick watch, at No. 6 Separator that alarms when oil is present in the OTCW flowing into No. 6 Separator. When this alarms, the Lakefront operator visually checks for the presence of oil in No. 6 Separator. The time for the OTCW to travel from the Refinery to No. 6 Separator is 1 to 2 hours, depending on the location within the Refinery. Similar instrumentation installed at key locations within the Refinery could provide advanced notice to the Lakefront operations to take timely response actions and could help identify the source of the oil coming into the OTCW system.

Solids are present in No. 6 Separator that have accumulated over time. The presence of these solids reduces the residence time of water and therefore decreases the effectiveness of No. 6 Separator to remove small droplets of oil entrained in the water.